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STUDY OF RELATIVE ROUGHNESS PITCH AND HEIGHT ON HEAT TRANSFER COEFFICIENT OF SOLAR AIR HEATER WITH ARTIFICIAL ROUGHNESS

KIRAN KUMAR. B[1], G. MUSALAIAH[2] & P. V. N. SAICHANDU[1]

[1]*Assistant Professor, Department of Mechanical Engineering, Hyderabad Institute of Technology and Management, Hyderabad, Telangana, India*

[2]*Assistant Professor, Department of Computer Science and Engineering, Institute of Aeronautical Engineering, Hyderabad, Telangana, India*

ABSTRACT

Solar air heater have low thermal performance because of development of the laminar sub region near the absorber wall to break this viscous sub layer and improve absorption efficiency experimental study shows that artificial roughness is the one of the best method. Artificial roughness created on the absorber plate in the form repeated rectangular inclined aluminum ribs which create turbulent flow inside the rectangular duct. Heat transfer of roughened duct is mainly depend on the Relative roughness pitch and relative roughness height parameter experimental study covers range of parameter relative roughness pitch (p/e) 33.89-88.23, relative roughness height from 0.012-0.021, by varying pitch 40mm, 50mm, 60mm of three different thickness diameter of wire 0.68mm, 0.87mm, 1.12mm by varying heat input values obtained are compared with smooth duct under similar flow conditions.

***KEYWORDS:** Relative Roughness, Heat Transfer Coefficient, Relative Roughness Pitch & Height*

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Original Article

1. INTRODUCTION

Energy shows a significant role in the development of the world. Renewable source is the alternative source of energy solar which is best renewable source, large quantity, non-pollutant and available at everywhere, with free of cost. Sun energy is collected by solar collector's There are three types of collector solar air heater, solar water heater and another one is photo voltaic methods.

There are 2 types of solar air collector's liquid flat plate collectors and air collectors. In air type collector absorber plate of high thermal conductivity is must. The absorbing plate of air collector should completely contact with air, there is no problem of corrosion of the plate, steel or aluminum plates can be used. Liquid type collector is commonly use of fin type in structure the absorbed heat is transferred to the liquid tubes by conduction. In air collectors, the air flow can be contact with entire absorbs the air by f plate surface. Hence, air heater type is considered to be cheaper and expected to be long life and there is no problem of pressurization, Leakage of fluid is not a problem compare to liquid type collectors.

2. LITERATURE REVIEW

- Sachin Chaudhary, Varun, Manish Kumar Chauha Concluded that M shape rib geometry has been investigated with different orientation, Reynolds number 3000-22000 roughness parameters range relative roughness height 0.038-0.074, relative roughness pitch 12.52-74.94 and angle 35-60°.
- Madhukeshwara N, E. S. Prakash conducted experimental study of heat transfer of turbulent flow of artificial roughened solar rectangular air heater duct with absorber plate having artificial roughness of V-shape wire ribs The experimental study range of parameters of geometry parameter relative roughness pitch from 10 to 30, relative roughness height from 0.012 to 0.04 angle of inclination 25 to 90 degree.
- Ankit C. Khandalwal, Samir. Dhatkar, Kanas-Pati Prasad S Analyse the fluid flow and heat transfer behaviour of artificial roughened by making the use of small diameter wire on walls (2 side walls,1top side) of duct. The range of geometry parameters values considered were relative roughness pitch of range 10 to 30, and relative roughness height 0.020-0.033.
- Prasad investigated experimentally how the artificial roughness effect on heat transfer characteristic of solar air heaters when G. I. wires various diameter are used on the absorber plate which is normal to the fluid flow direction the range of parameter are relative roughness height, 0.0092 to 0.026 and the range of relative roughness pitch, 10–40. The Reynolds number 2859–12531, The maximum thermal efficiency of roughened solar air heaters 1.842 when compare to those of the smooth solar air heaters.

3. POSED GEOMETRY OF ROUGHNESS

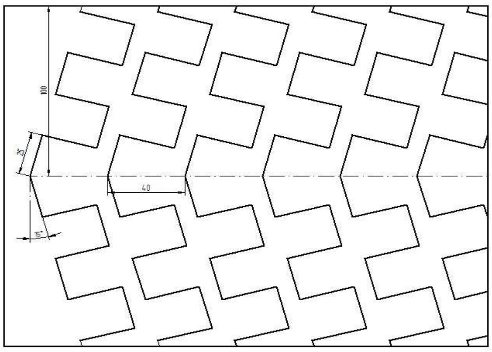

Figure 1: Roughness Geometry of α=15˚, Pt=25mm, P=40mm

4. METHODOLOGY

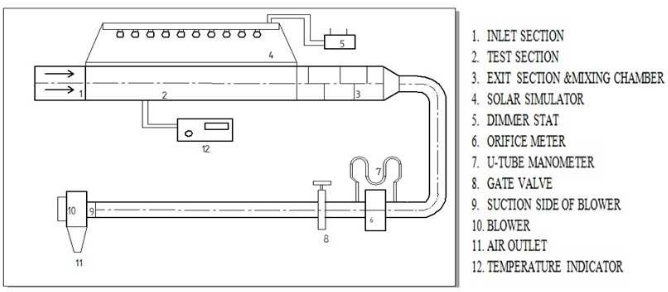

Figure 2: Schematic Line Diagram of Experimental set-up

5. EXPERIMENTAL PROCEDURE

All component parts of experiment setup have been checked for appropriate condition. Place the absorber plate on test section in which bottom side aluminium wire ribs are glued on the traced geometry then allow to dry then place the thermocouples on plate connect to the temperature indicator close the simulator.

Then Ensure that no leakage in duct and pressure tapping. heat input is given to the test section by electric bulbs using dimmer stat for one hour After an hour steady state condition The blower is switched on and flow control valve is adjusted to give a predetermined rate of air flow to the test section 4 different flow of air are used for each heat input to the absorber plate. After next flow rate reading were taken after attaining steady state.

During the experiments parameter which need to collect.

- Change in Pressure across orifice meter.
- Temperature of air at inlet and exit section.
- Surface Temperature at various location of absorber plate.
- Power supply to bulbs in terms of voltage and current.

6. RESULTS AND DISCUSSIONS

To compare the Heat Transfer Coefficient of Rough ended plate with smooth plate graph and table for Reynolds number along x axis and heat transfer coefficient along Y axis is plot for 40w, 63w, heat input for four different air flow rate and for three pitch 40mm,50mm,60mm

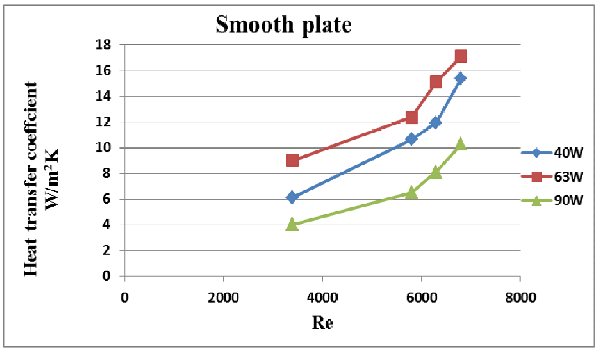

Figure 3

Table 1

Q in Watts	Heat Transfer Coefficient for Different Reynolds Number in W/m²K			
	3400	**5800**	**6300**	**6800**
40	6.13	10.62	11.93	15.38
63	8.98	12.36	15.1	17.09
90	4.02	6.5	8.11	10.25

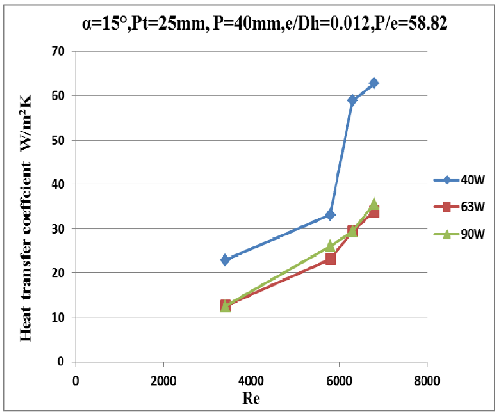

Figure 4

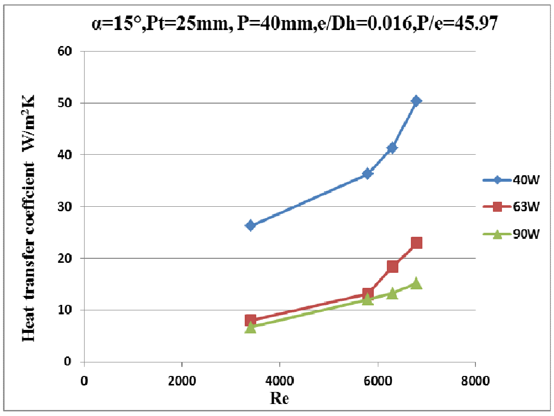

Figure 5

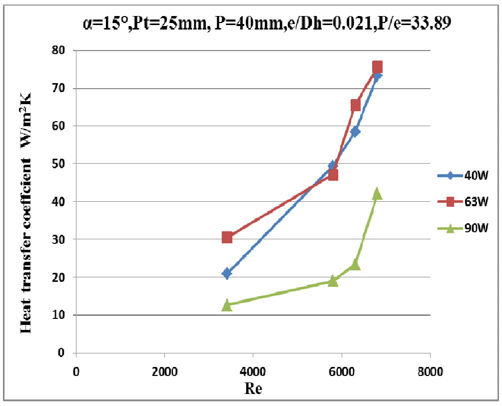

Figure 6

From the literature review it is concluded that inclined ribs more transfer of heat than the transvers ribs because by inclined ribs Cause to occur rapidly secondary flow yield local wall turbulence. Secondary flow join vicinity of the main stream and leading to rise in heat transfer Graphs plotted for different relative roughness height at 15º of angle of flow maximum coefficient of heat transfer recorded at15º at pitch between the ribs 40mm is 75.62W/m^{2}K. by considering this angle, distance between the ribs are changed to 50mm and 60mm relative graphs are plotted

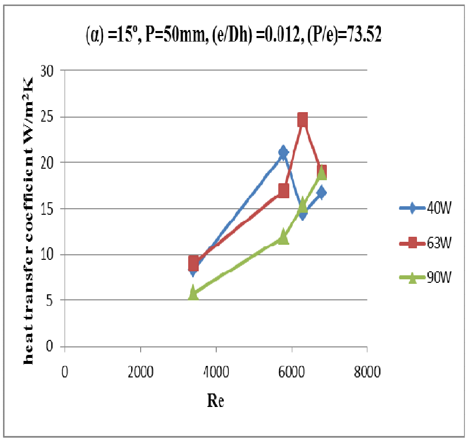

Figure 7

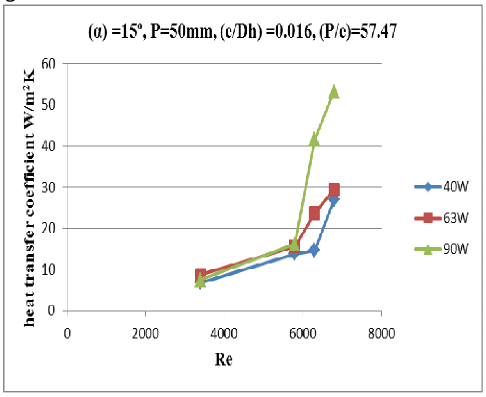

Figure 8

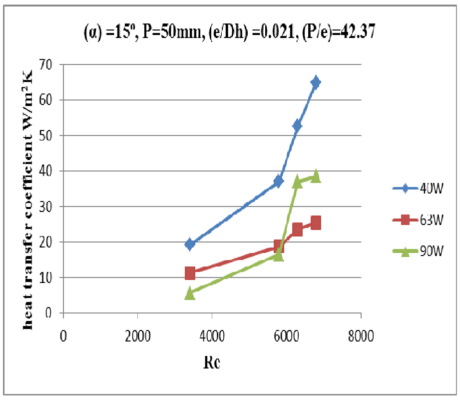

Figure 9

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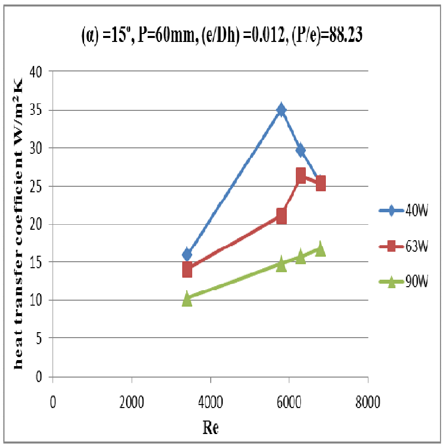

Figure 10

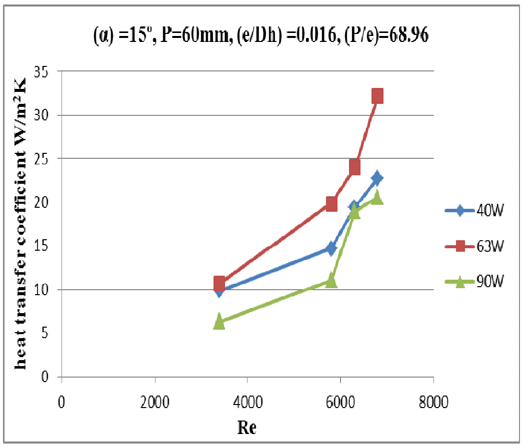

Figure 11

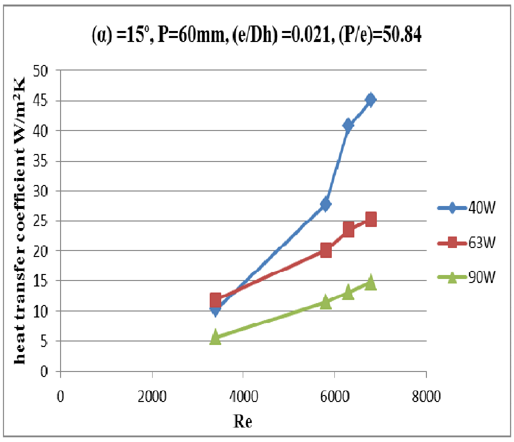

Figure 12

From it is observed that maximum transfer of heat occur for roughness pitch 60mm,(e/Dh)0.021 and (P/e) 50.24 is 45.09 W/m^2K it is observed that 60mm is highest roughness pitch where the reattachment points are less compare to 40 and 50mm there for less heat transfer coefficient occur compare to the 40mm and 50mm pitch.

On the basis of results discussions obtained are as follows:

- For roughness pitch 40mm & for 3 relative roughness pitch 33.89, 45.97&58.82 maximum Heat transfer co-efficient observed 75.62W/m2K.
- For roughness pitch 50mm & for 3 relative Roughness pitch 42.37, 57.47&73.52 maximum Heat transfer co-efficient observed 52.58W/m2K.
- For roughness pitch 60mm & for 3 relative roughness pitch 50.84, 68.96, 88.23 Heat transfer co-efficient varies observed 45.09W/m2K.
- Heat transfer coefficient for relative roughness height (e/Dh) 0.012 varies from5.81 to 62.8W/m2K for different heat input.
- Heat transfer coefficient for roughness height (e/Dh) 0.016 varies from 6.31 to 50.41W/m2K for different heat input.
- Heat transfer coefficient for roughness height (e/Dh) 0.021 varies from 5.65 to 75.62W/m2K for different heat input.

7. CONCLUSIONS AND SCOPE FOR FUTURE WORK

From the experimental investigation on solar air heater duct with artificial roughness, the following conclusions can be made.

- Maximum heat transfer takes place for a relative roughness pitch of 33.89.
- Maximum heat transfer takes place for a relative roughness height of e/Dh=0.021,
- Maximum heat transfer takes place for a roughness pitch of 40mm at a roughness height 1.12mm is 75.62W/m2K.

8. SCOPE FOR FUTURE WORK

In future work,

- for different type of geometry parameter
- for different materials,
- for different flow rate project can be done.

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